

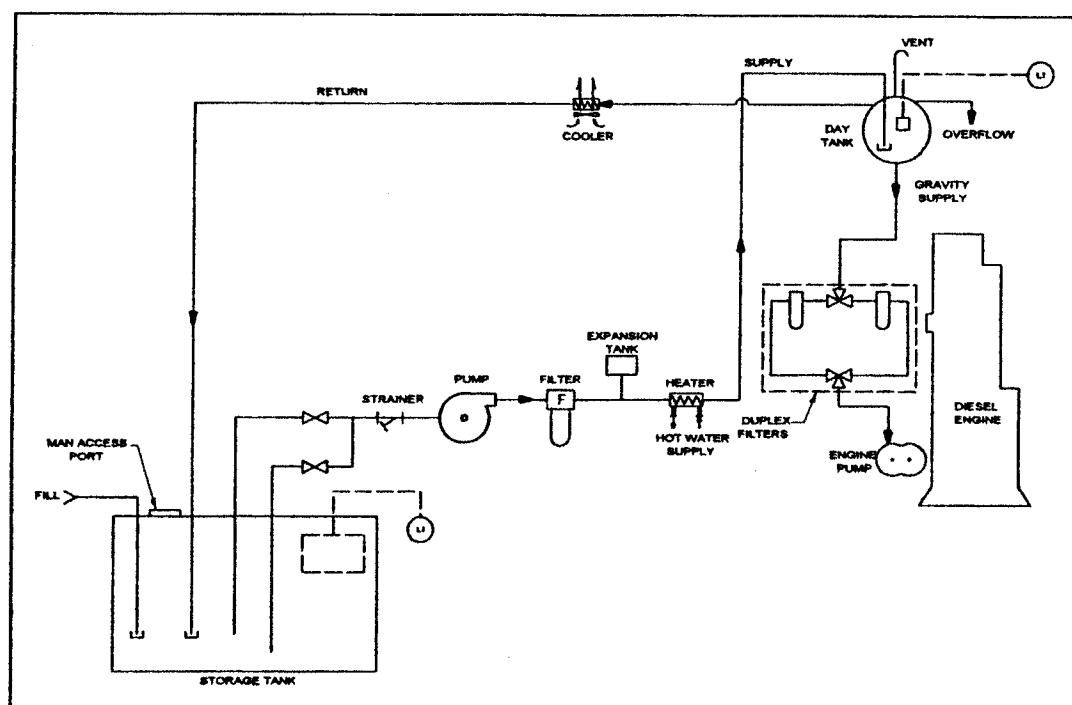
## CHAPTER 5

### GENERATORS AND ANCILLARY EQUIPMENT

#### 5-1. Description of generator ancillary equipment, diesel fuel, and lube oil systems

Generators are used to supply primary power, standby power, and emergency power. The generators used at Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) facilities are most often powered by diesel engines. Commissioning of a standby power system addressing the generator and electrical aspects of standby power are discussed in Army TM 5-694. This technical manual will address the ancillary equipment consisting of a typical diesel fuel and lube oil system.

*a. Diesel fuel system.* A diesel fuel system is shown in figure 5-1, Schematic of a typical diesel fuel system. The system consists of a storage tank, strainer, motor driven pump, filter, expansion tank, heater, day tank, cooler, engine mounted duplex filter, and engine mounted pump.



*Figure 5-1. Schematic of a typical diesel fuel system*

*b. Lube oil system.* A lube oil system is shown in figure 5-2, Schematic of a typical lube oil system. The system consists of a clean lube oil tank, dirty lube oil tank, pumps, lube heaters, cooler, centrifuge, duplex filter, and duplex strainer.

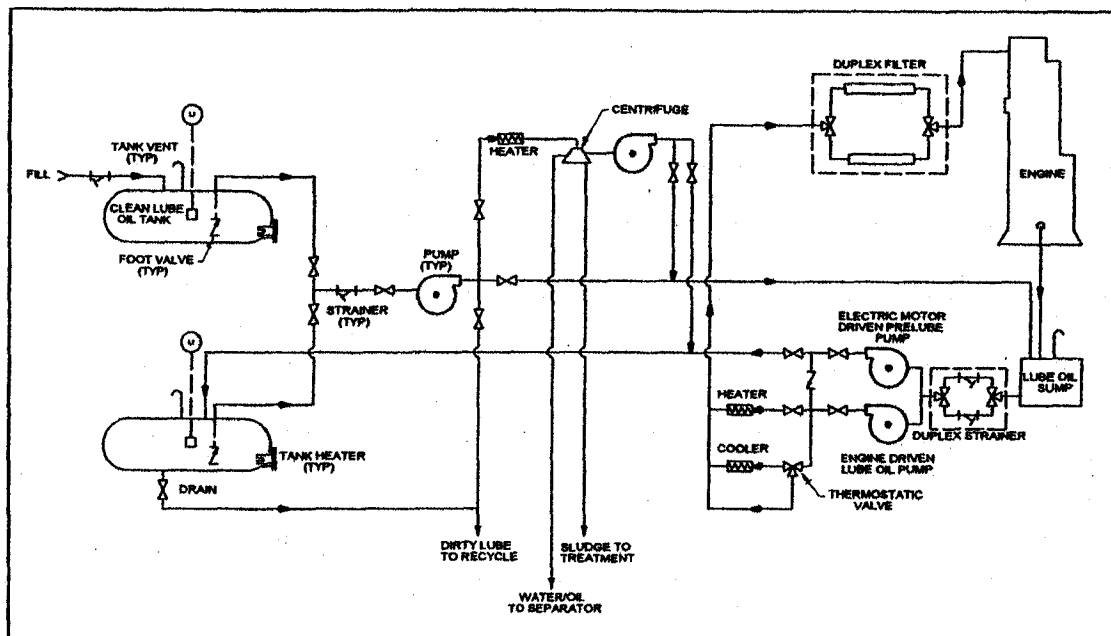


Figure 5-2. Schematic of a typical lube oil system

c. *Diesel fuel and lube oil systems.* More information on design, maintenance, and testing of diesel fuel and lube oil systems, and generators is found in the American Society of Mechanical Engineers (ASME): B 31.3, Process piping, Army TM 5-692-1 Maintenance of Mechanical and Electrical Equipment at C4ISR Facilities, Recommended Maintenance Practices, chapters 5, 6 and 19, Army TM 5-692-2 Maintenance of Mechanical and Electrical Equipment at C4ISR Facilities, System Design Features, chapters 5, 6 and 19, Army TM 5-685 Operation, Maintenance and Repair of Auxiliary Generators, and Army TM 5-694 Commissioning of Electrical Systems for C4ISR Facilities, chapter 5.

## 5-2. Operation of diesel fuel system and lube oil systems

A discussion of the operation of the diesel fuel and lube oil systems is presented in the following paragraphs.

a. *Diesel fuel system operation.* The diesel fuel storage tank shown in figure 5-1, Schematic of a typical diesel fuel system, must be a double wall tank or, when located above ground, a single wall tank surrounded by a dike for containment of a leak, can be used. For underground installations, the tank must be double wall with a leak detection system monitoring the annulus between walls. The tank is provided with level indication, either local, remote, and/or is interlocked to shut off fill flow. The tank is provided with a fill line, man access port, return line, and two suction lines. The tank may be provided with suction line heaters or a tank heater (not shown) depending on the engine's fuel requirement and type of diesel fuel selected. The fill line and the return lines are provided with traps to minimize the formation of vapors in the tank. One suction line is located higher than the other. Normally the pump will draw from the low suction line. As water separates from the fuel it will approach the lower suction line. If water is picked up in this line, the pump can be switched to the upper suction line until the water is removed through the man access port. A strainer provides a coarse means of particulate removal upstream of the pump. A coalescing filter provides for water and fine particulate removal downstream of the pump. An expansion tank may be installed to prevent expanding oil from leaking from joints and

shaft seals. An oil heater may be installed depending on the type of oil and climate, to reduce oil viscosity to the atomizing range. The oil then enters the day tank and is discharged through a trap. The day tank holds a four- to eight- hour supply of fuel and is mounted above, or in close proximity to, the generator's diesel engine. It is provided with a vent, overflow, return line, and gravity feed line to the duplex engine filters, a pump and a level indication, either local, remote, and/or interlocked to shut off supply flow. The engine's positive displacement pump raises the diesel fuel to the correct pressure for engine operation and distributes it to the fuel injectors. An oil cooler is provided, when needed, in the return line to minimize flashing and formation of vapors. Oil lines may be electrically or steam heat traced for winter service depending on the type of fuel, climate, and installed pipe location.

*b. Lube oil system operation.* As shown in the lube oil system in figure 5-2, Schematic of a typical lube oil system, new lube oil passes through a strainer before entering the clean lube tank. The tank is provided with level indication, either local, remote and/or is interlocked to shut off fill flow. The tank is also equipped with a vent and a heater if required. The dirty lube tank incorporates a drain, level indication, vent, return line, and suction line.

(1) A pump draws lube oil through a strainer and foot valve in either tank. The foot valve prevents the line from emptying when not in use. From this pump, lube oil can flow to the engine lube oil sump, to a tanker truck for hauling to an oil recycle center, or it can be heated and cleaned through a centrifuge. From the centrifuge, water/oil discharge is sent to a separator, sludge is sent to treatment for disposal, and the treated lube is sampled. The treated lube if clean is pumped to the engine lube oil sump, or if dirty it is pumped to the dirty lube oil tank.

(2) From the engine lube oil sump, lube oil is pumped through a duplex strainer by a motor driven pump or an engine driven pump. As with duplex filters, duplex strainers provide for continuous operation. Switching from one strainer to the other can take place without impeding oil flow by switching the inlet and outlet three-way valves simultaneously. This permits cleaning of one strainer while the other is in service. When the standby power engine requires warm engine lube and a warm engine block for startup, the electric motor driven pump continuously circulates engine lube through a heater. Once the engine is started the engine driven lube oil pump will take over and lube will flow through a thermostatic valve to a cooler and by-pass line to maintain correct engine lube temperature for operation. The lube oil flows through a duplex filter before entering the engine. The electric motor driven pump can also be used as a pre-lube pump to circulate lube prior to starting the engine and after the engine shuts down for controlled cooling. The pump also transfers dirty lube from the engine lube oil sump to the dirty lube oil tank.

(3) The lube oil system may be integral with the engine or may be provided as a separate skid mounted unit. Lube oil tanks, pipes, and lines may be heated or heat traced. Controls, alarms, and engine shutdown interlocks are provided as needed and include alarms for low oil flow, low oil level, low oil pressure, low oil temperature, high oil temperature, or high filter differential pressure.

### **5-3. Pre-functional test plan and functional performance test plan for diesel fuel and lube oil systems**

This manual assumes that individual components and packaged equipment have been tested by the manufacturer. As part of the commissioning effort each component should be checked for damage, deterioration, and failures by a procedure using inspections and tests as defined by the specific equipment manufacturers. Equipment manuals from manufacturers identify the minimum required receipt inspections, handling and installation procedures, drawing and wiring verification, field

inspection and installation checks, verification of removal of shipping braces, inspection of installation against drawings and nameplates, inspection of components for damage and cleanliness, inspection of insulators and grounding, inspection of anchorage and alignment, adjustment checks, mechanical operation and interlock checks, lubrication application, and verification that local safety equipment is in place.

*a. Safety, diesel fuel and lube oil systems.* Many tests on equipment involve the use of high voltages, high currents, pressurized fuel, and rotating or moving equipment. These can be dangerous to personnel and damaging to equipment. A procedure should be followed to insure adequate safety rules are instituted and practiced to prevent injury to personnel performing the tests and other personnel who might be in the local area.

*b. Test equipment, diesel fuel and lube oil systems.* It is important that in any test program the proper equipment is used. The equipment should be calibrated, in good condition, and used by qualified operators as required by a procedure. Any test equipment used for calibration shall have twice the accuracy of the equipment to be tested. All equipment should be operated in accordance with its instruction manual. A procedure defining installation inspection and a system test needs to be provided.

*c. Inspection checklists, diesel fuel and lube oil systems.* An inspection checklist for the systems are presented in figure 5-3, Example of a completed DA Form 7480-R, diesel fuel system inspection checklist and figure 5-4, Example of a completed DA Form 7481-R, lube oil system inspection checklist.

#### **5-4. Possible failures and corrective measures for diesel fuel and lube oil systems**

Table 5-1 on page 5-7 lists general problems that may arise during the testing of equipment and systems along with possible troubleshooting techniques. For all problems, consult equipment and component manuals for troubleshooting directions. Check fuses/lights/breakers/etc., for continuity, check equipment calibration and settings, check for clogged filters and strainers, check for closed manual shutoff valves and dampers, check for improperly adjusted valves and equipment, and look for faulty equipment and connections.

<b>DIESEL FUEL SYSTEM INSPECTION CHECKLIST</b> For use of this form, see TM 5-697; the proponent agency is COE.						
<b>SECTION A - CUSTOMER DATA</b>						
1. PLANT Redundant Power		2. LOCATION Building 10		3. JOB NUMBER RP-22		
4. EQUIPMENT Fuel Oil System - 1		5. SYSTEM DESIGNATION FOS - 1		6. DATE (YYYYMMDD) 20021125		
7. TEST EQUIPMENT Graduated Story pole, tank level chart, Fluke multimeter				8. TESTED BY Bob Hale		
<b>SECTION B - EQUIPMENT DATA</b>						
9. PUMP MANUFACTURER Oberdorfer		10. MODEL NO N993-03		11. SERIAL NO T10063		12. FLOW RATING GPM 8 gpm
13. TYPE Gear Pump		14. HP @ RPM NA		15. PRESSURE RATING PSIG NA		
16. HEATER MANUFACTURER		17. MODEL NO NA		18. SERIAL NO NA		19. FLOW RATE GPM NA
20. COOLER MANUFACTURER		21. MODEL NO NA		22. SERIAL NO NA		23. FLOW RATE GPM
<b>SECTION C - VISUAL AND MECHANICAL INSPECTION</b>						
24.	CHECK POINT	COND *	NOTES	CHECK POINT	COND *	NOTES
	EXTERIOR OF EQUIPMENT	A		EQUIPMENT IDENTIFICATION	A	
	COMPLETENESS OF ASSEMBLY	A		BRACING	A	
	EQUIPMENT ROTATION	A		LABELING AND TAGGING	A	
	ELECTRICAL/MECHANICAL INTERLOCKS	A		SAFETY INTERLOCKS	A	
	INSTRUMENTS	A		WORKING SPACE	A	
	PROPER GROUNDING	A		ANCHORAGE	A	
	PROPER INSULATION	NA		LEAKS	A	
	TIGHTNESS OF BOLTED CONNECTIONS	A		COMPARISON TO DRAWINGS	NA	
	PROPER LUBRICATION	NA		CONTROL SYSTEM	A	
<b>SECTION D - CALIBRATION AND SET POINT</b>						
25.	DESCRIPTION					NOTES
	SENSORS Main tank levels are consistent with sensor reading.					1
	CONTROLLERS Main tank controllers indicate all conditions normal					
	ACTUATORS NA					
<b>SECTION E - DIESEL FUEL SYSTEM TESTS</b>						
26.	OPERATING MODES	TEMPERATURES	PRESSURES	FLOWS	LEVELS	NOTES
	PUMP Auto	55 degrees F	3 psi	8 gpm		
	HEATER NA					
	COOLER NA					
	ENGINE NA					
	HYDROSTATIC TEST NA					
	SYSTEM TEST performed annually					
27. NOTES 1. Tank level was taken with Story pole and calculated using tank chart.						
*CONDITION: A - ACCEPTABLE; R - NEEDS REPAIR, REPLACEMENT OR ADJUSTMENT; C - CORRECTED; NA - NOT APPLICABLE						

Figure 5-3: Example: DA Form 7480-R

<b>LUBE OIL SYSTEM INSPECTION CHECKLIST</b> For use of this form, see TM 5-897; the proponent agency is COE.						
<b>SECTION A - CUSTOMER DATA</b>						
1. PLANT East Building		2. LOCATION Washington, DC		3. JOB NUMBER EB-13		
4. EQUIPMENT		5. SYSTEM DESIGNATION		6. DATE (YYYYMMDD) 20021126		
7. TEST EQUIPMENT Fluke calibrated multimeter, pressure gauge				8. TESTED BY Roger Swanson		
<b>SECTION B - EQUIPMENT DATA</b>						
9. PUMP MANUFACTURER Oberdorfer		10. MODEL NO N993		11. SERIAL NO 7580		12. FLOW RATING GPM 2 gpm
13. TYPE Gear Pump		14. HP @ RPM .5 @ 1800		15. PRESSURE RATING PSIG 40 psig		
16. HEATER MANUFACTURER NA		17. MODEL NO		18. SERIAL NO		19. FLOW RATING GPM
20. COOLER MANUFACTURER NA		21. MODEL NO		22. SERIAL NO		23. FLOW RATING GPM
24. CENTRIFUGE MANUFACTURER RCI		25. MODEL NO RC - 1500		26. SERIAL NO 0954KJ9		27. FLOW RATING GPM 150 gpm
<b>SECTION C - VISUAL AND MECHANICAL INSPECTION</b>						
28.	CHECK POINT	COND*	NOTES	CHECK POINT	COND*	NOTES
	EXTERIOR OF EQUIPMENT	A		EQUIPMENT IDENTIFICATION	A	
	COMPLETENESS OF ASSEMBLY	A		BRACING	A	
	EQUIPMENT ROTATION	A		LABELING AND TAGGING	A	
	ELECTRICAL/MECHANICAL INTERLOCKS	A		SAFETY INTERLOCKS	A	
	INSTRUMENTS	A		WORKING SPACE	A	
	PROPER GROUNDING	A		ANCHORAGE	A	
	PROPER INSULATION	A		LEAKS	A	
	TIGHTNESS OF BOLTED CONNECTIONS	A		COMPARISON TO DRAWINGS	A	
	PROPER LUBRICATION	A		CONTROL SYSTEM	A	
<b>SECTION D - CALIBRATION AND SET POINT</b>						
29.	DESCRIPTION					NOTES
	SENSORS Level and pressure sensors in both day and storage tanks OK					
	CONTROLLERS Simplex control system OK					
	ACTUATORS Fuel control valves activated fully for fuel transfer					
<b>SECTION E - LUBE SYSTEM TESTS</b>						
30.	OPERATING MODES	TEMPERATURES	PRESSURES	FLOWS	LEVELS	NOTES
	PUMP Auto	NA	40 psig	2 gpm		
	HEATER NA					
	COOLER NA					
	ENGINE Auto	195 degrees F	NA	NA		
	HYDROSTATIC TEST NA					
	SYSTEM TEST performed monthly					
31. NOTES						
*CONDITION: A - ACCEPTABLE; R - NEEDS REPAIR, REPLACEMENT OR ADJUSTMENT; C - CORRECTED; NA - NOT APPLICABLE						

Figure 5-4: Example: DA Form 7481-R

*Table 5-1. Possible failures and corrective actions for diesel fuel and lube oil systems*

	Areas to Check
<b>General Controls</b>	
Devices will not close/trip	Check mechanical alignment of limit switches Check interlocks and safeties Check relay and protective device settings and operation Check for mis-wired circuits Check control circuit Check controller set point
Devices trip inadvertently	Check relay and protective device settings and operation Check for mis-wired circuits Check the control circuit Check for system overload or short Check grounds
<b>Diesel Fuel System</b>	
Will not start or starts but shuts down	Check power supply Check controls, switches, starters, and disconnects Check controller set points, temperatures, pressures, levels Check sensors, actuators, and indicators Check heaters Check filters Check fuel level and fuel quality Check safeties and interlocks to fire protection systems
Incorrect fuel flow or no fuel flow	Check pumps Check controls and set point Check filters Check for closed shut off valves Check safeties and interlocks to fire protection systems
<b>Lube Oil System</b>	
Will not start or shuts down	Check power supply Check controls, switches, starters and disconnects Check controller set points, temperatures, pressures, levels Check sensors, actuators and indicators Check filters Check lube oil level Check safeties and interlocks
Incorrect lube oil flow or no lube oil flow	Check pumps Check centrifuge Check controls and set point Check heaters Check filters Check for closed shut off valves Check safeties and interlocks to fire protection systems